

CS4195 Modelling and Data Analysis in Complex Networks

Navigation on Temporal Networks

Outline

- Background
- Method 1: Wait For Mid-nodes (WFM)
- Method 2: Greedy Navigation with Shortest Path (GNSP)
- Weighted Temporal Network
- Conclusion

Background

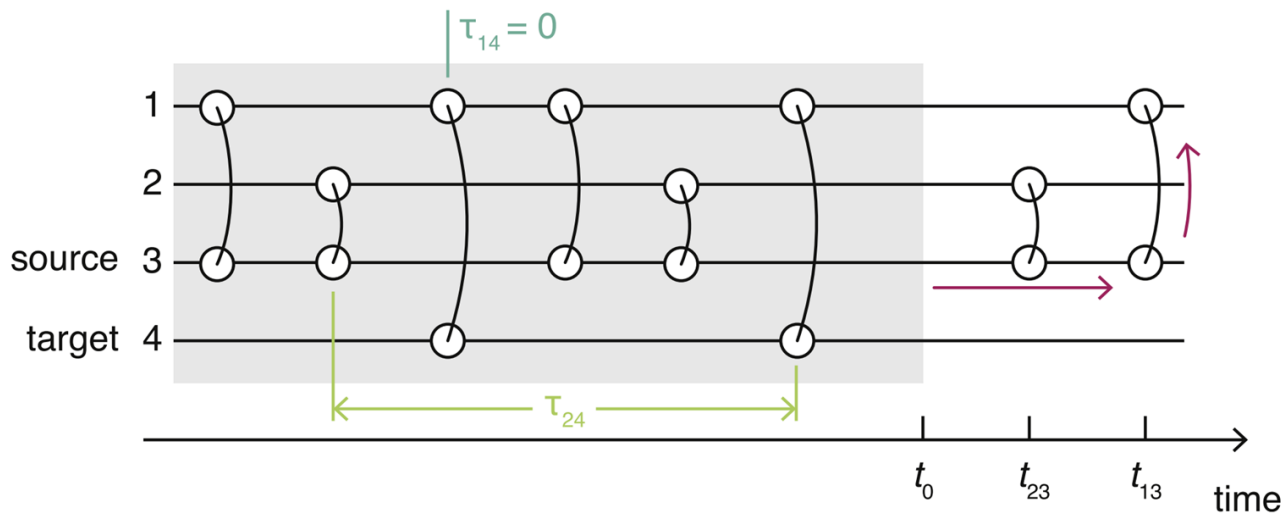
WFM

GNSP

Weighted

Conclusion

Greedy Navigation



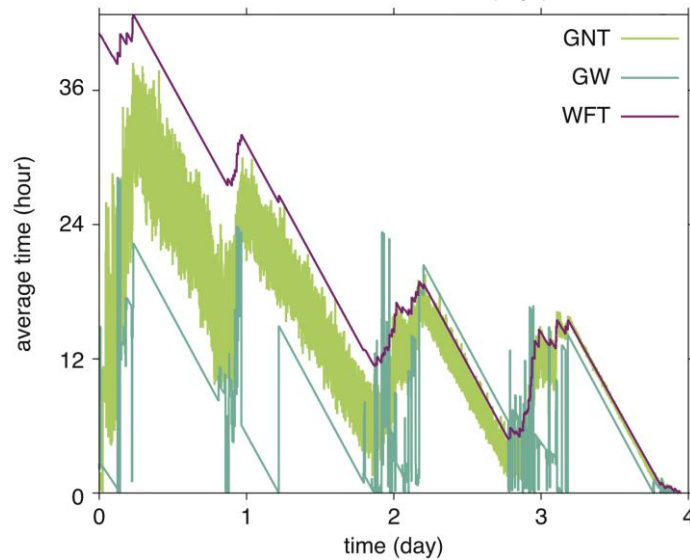
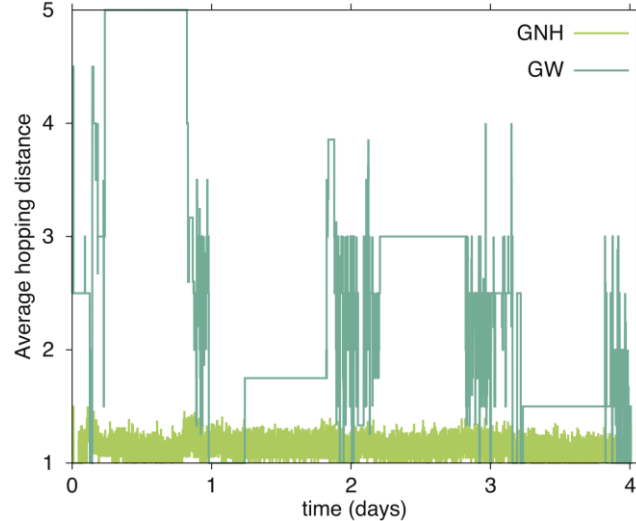
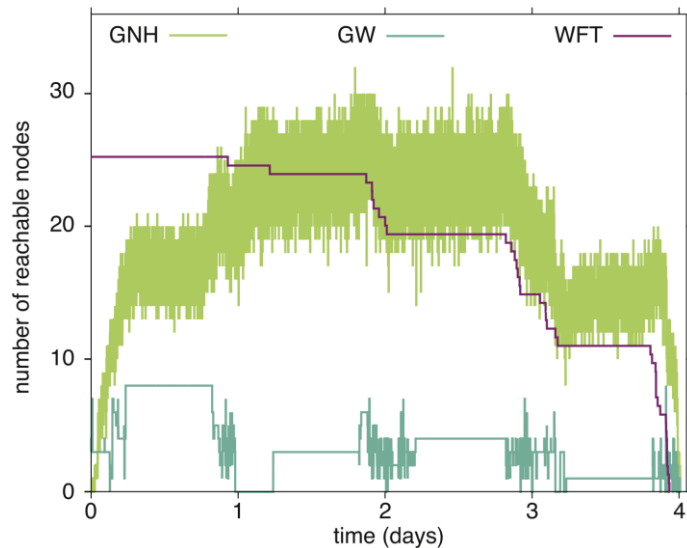
“if a walker at node 3 tries to move to node 4 at time $t = t_0$, as the node ‘closest’ to the target (node 4) is node 1, node 3 indefinitely waits for an interaction with node 1 ($t = t_{13}$), even if the interaction between node 3 and node 2 happens (at $t = t_{23}$) prior to the interaction between node 3 and node 1. Once the walker reached from node 3 to node 1, the walker at node 1 will wait for the direct interaction with node 4 (one step or $\tau = 0$ to the target) and finalize the active navigation.”[1]

[1] S. H. Lee and P. Holme, “Navigating temporal networks,” *Physica A: Statistical Mechanics and its Applications*, vol. 513, pp. 288–296, 2019.

Key Definitions

- GNH: greedy navigation strategy based on the hopping distance;
- WFT: wait for target;
- Information network: temporal network before t_0 ;
- Navigation network: temporal network after t_0 .

Evaluation Measures

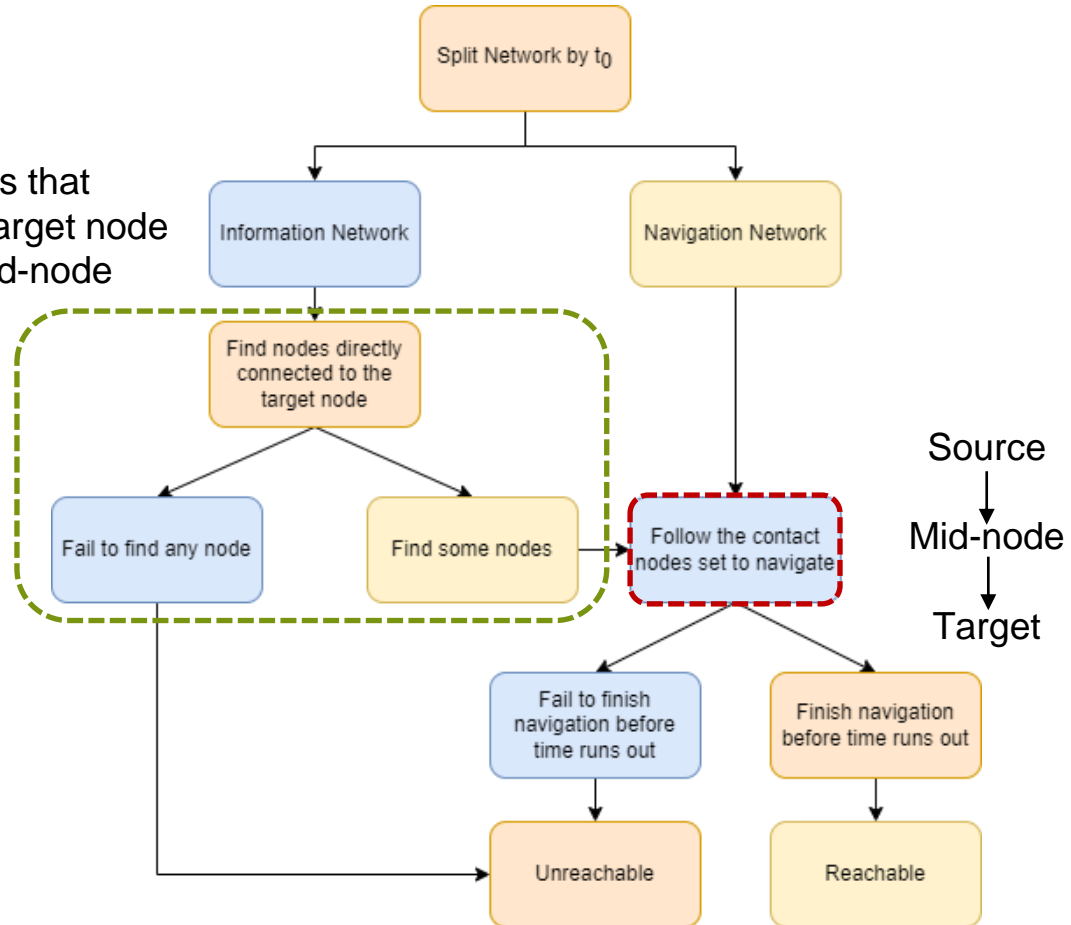


Objective: Reachability

Wait for Mid-nodes

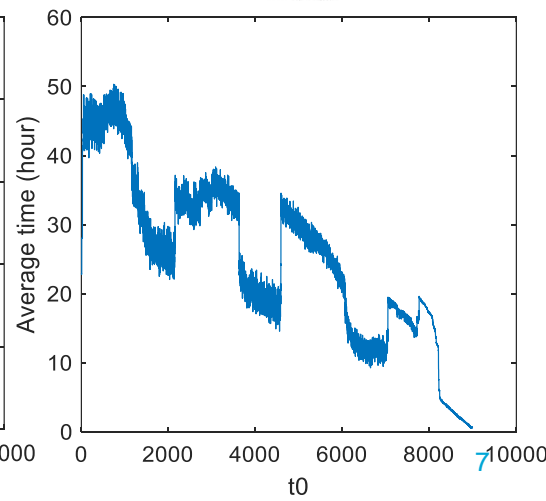
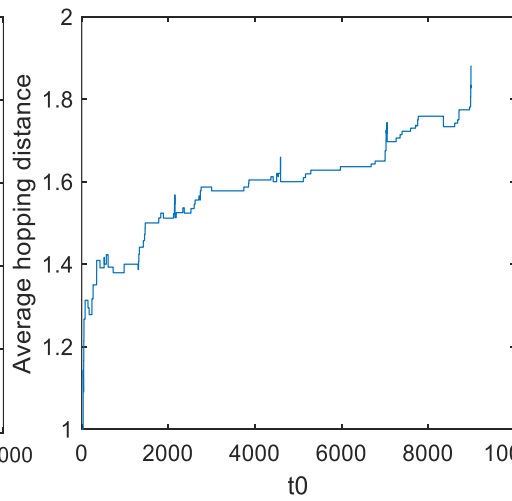
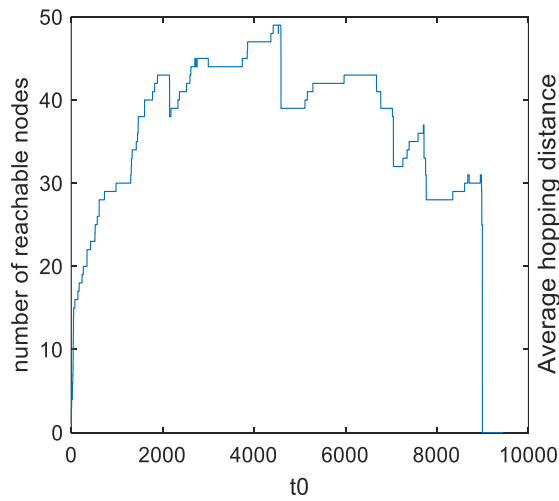
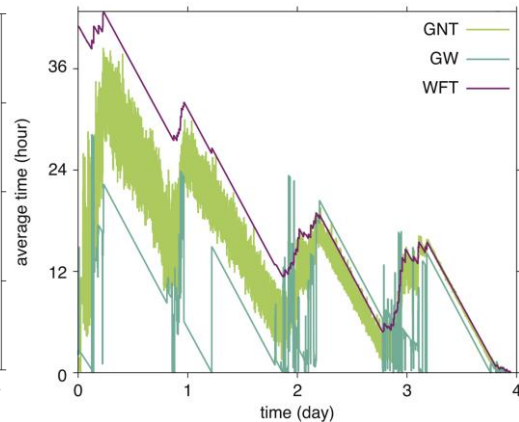
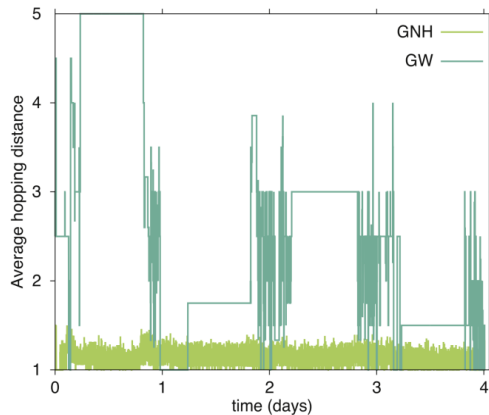
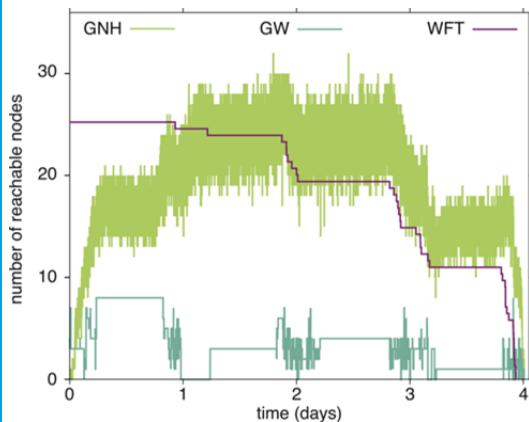
Background
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Consider nodes that
connected to target node
as potential mid-node



Results-Node 51 as source node

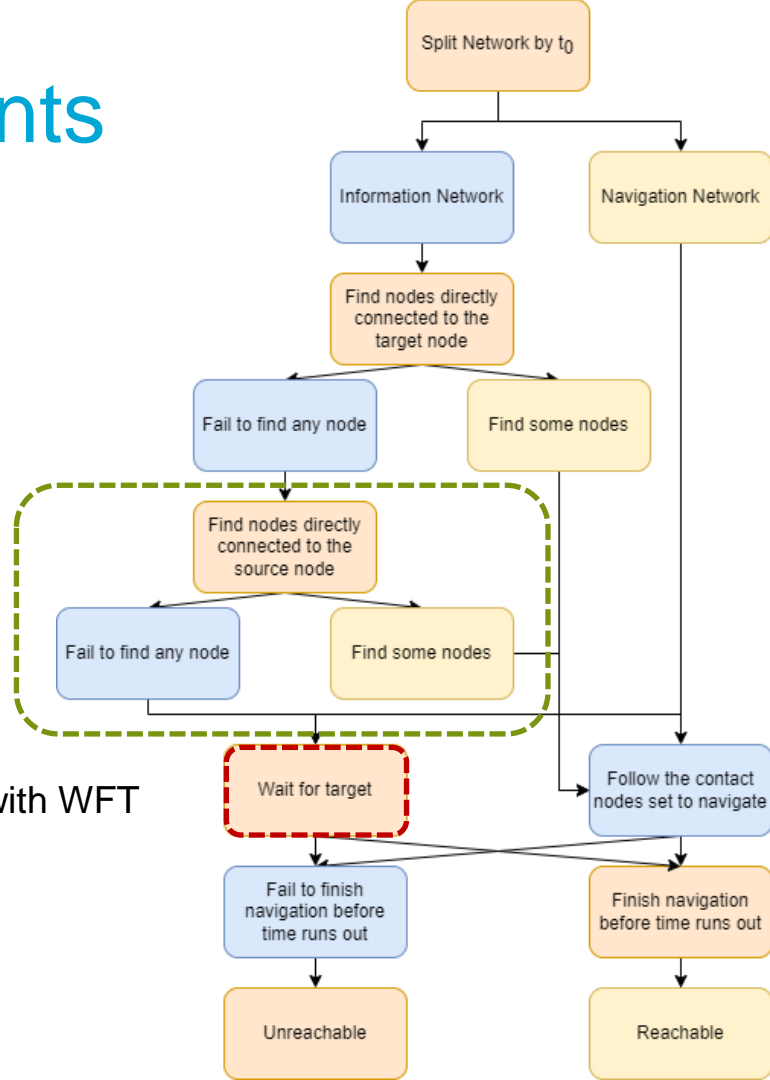
Background
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Improvements

Also consider nodes that connected to source node as mid-node

Combine with WFT



Results-Reachability of Node 51

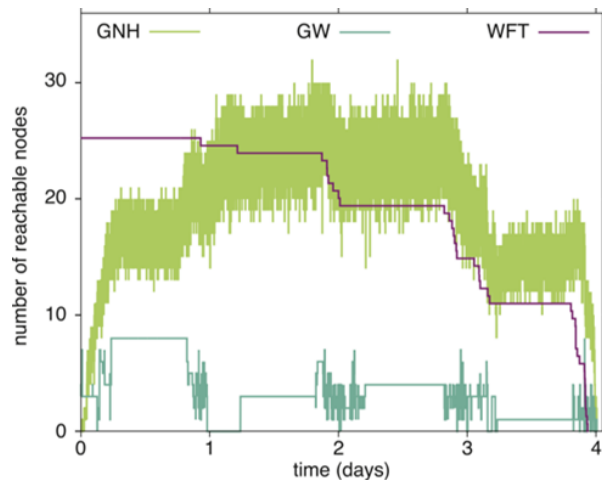
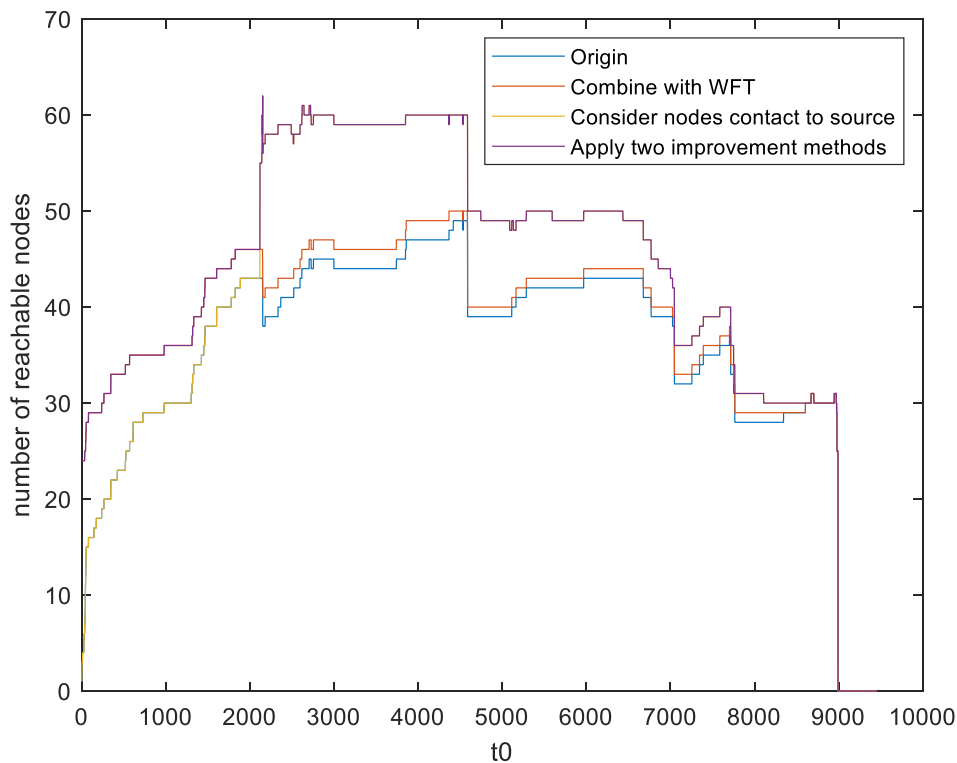
Background

WFM

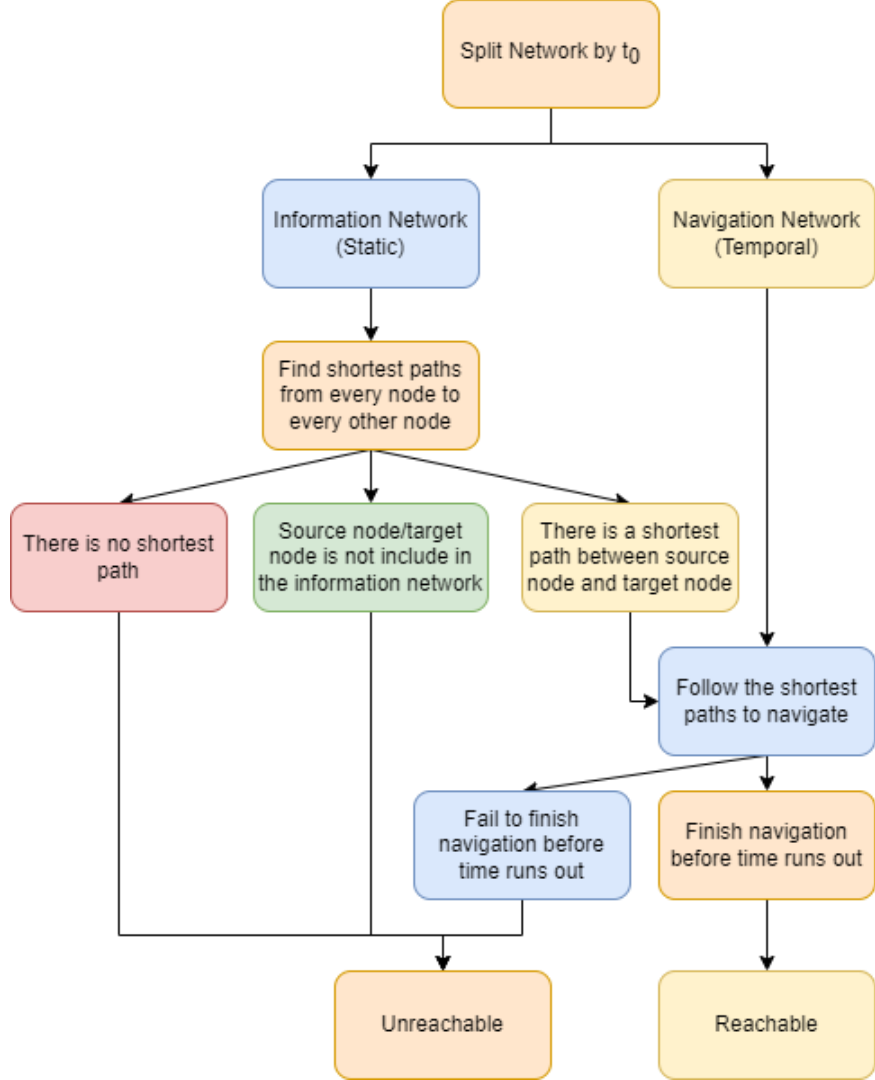
GNSP

Weighted

Conclusion

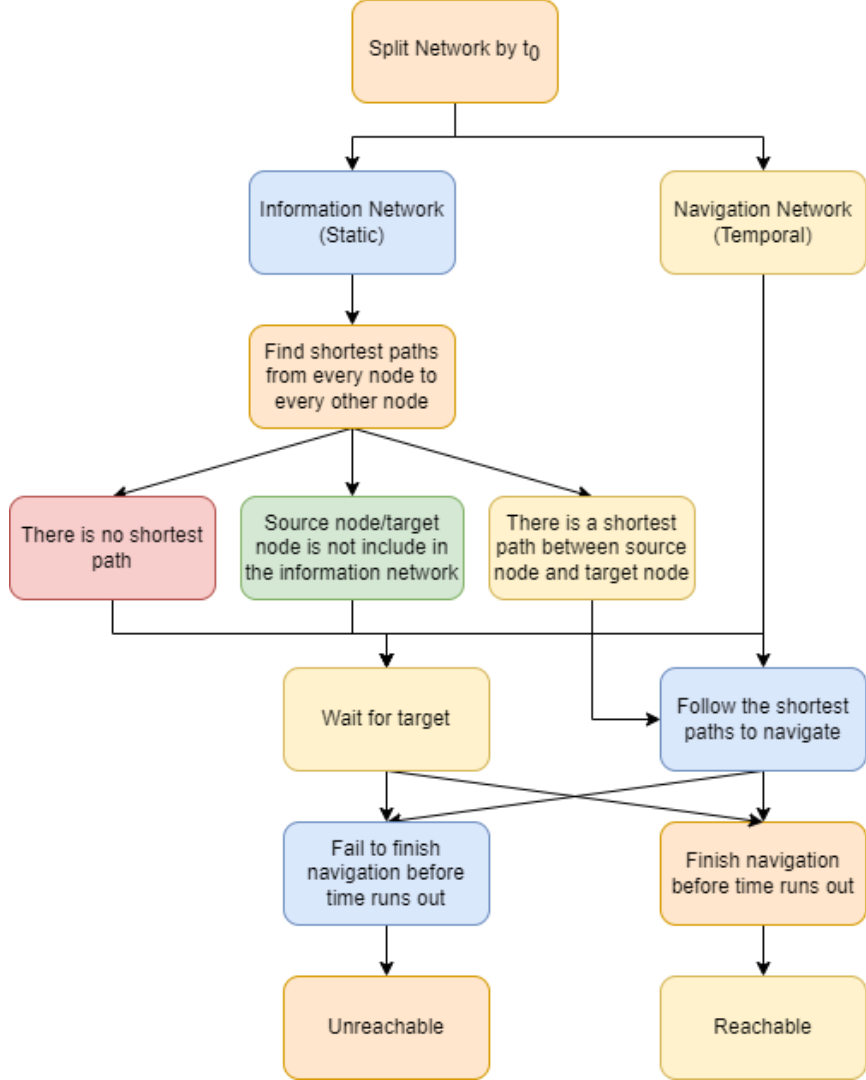


Greedy Navigation with Shortest Path



Background
WFM
GNSP
Weighted
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Simply combine GNSP and WFT

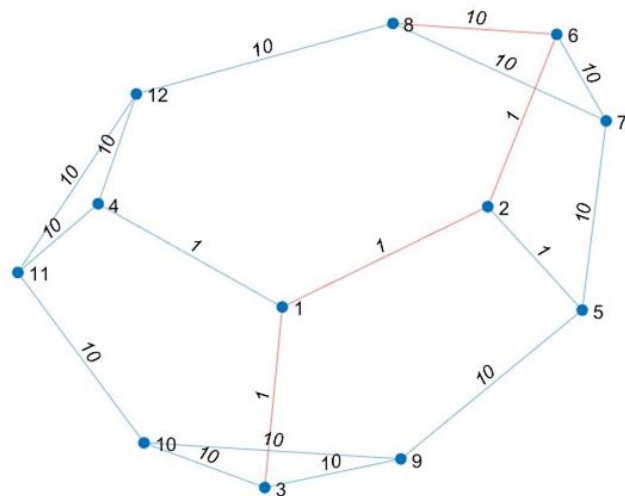
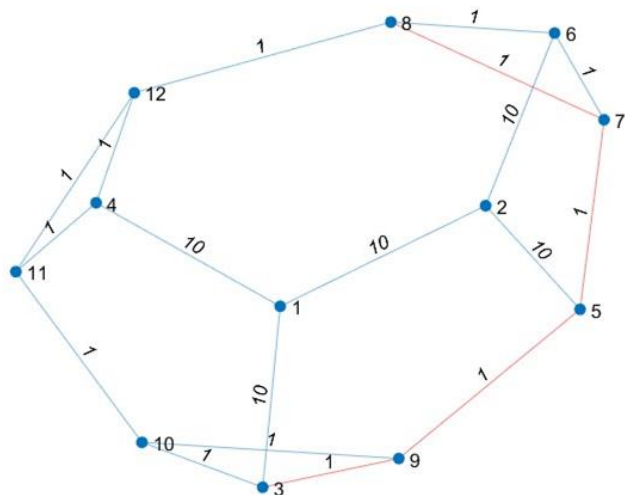


Background
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Weighted Temporal Network

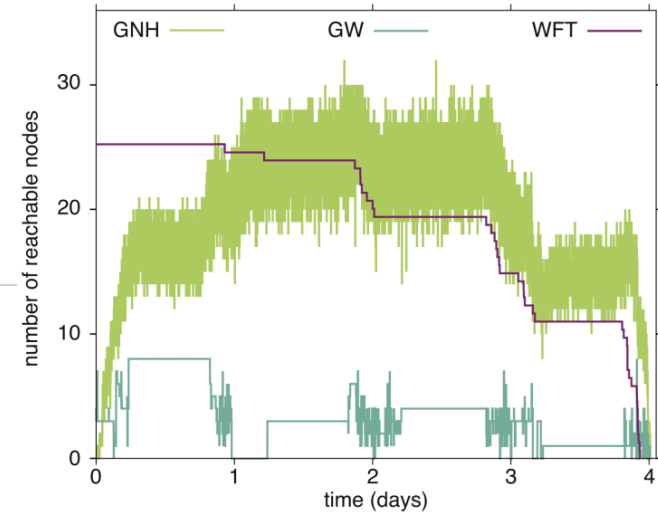
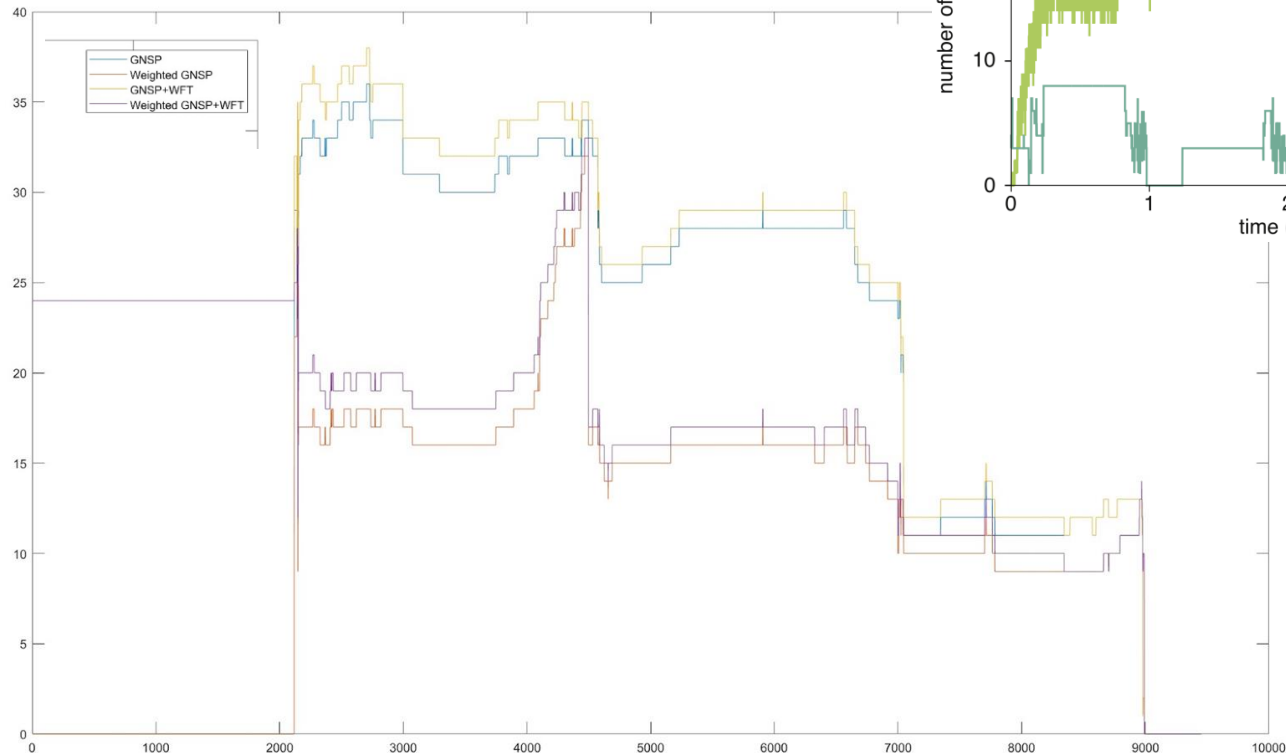
- Definition: the weight between a node pair equals the total number of contacts between the node pair;
- General definition: the shortest path of a weighted network means finding the path with the **least** weight;
- In our task, we should look for the path with the “maximum” weight. The path with high weight in the information network leads to high probability of appearing in the navigation network.

Reconstruct Weight



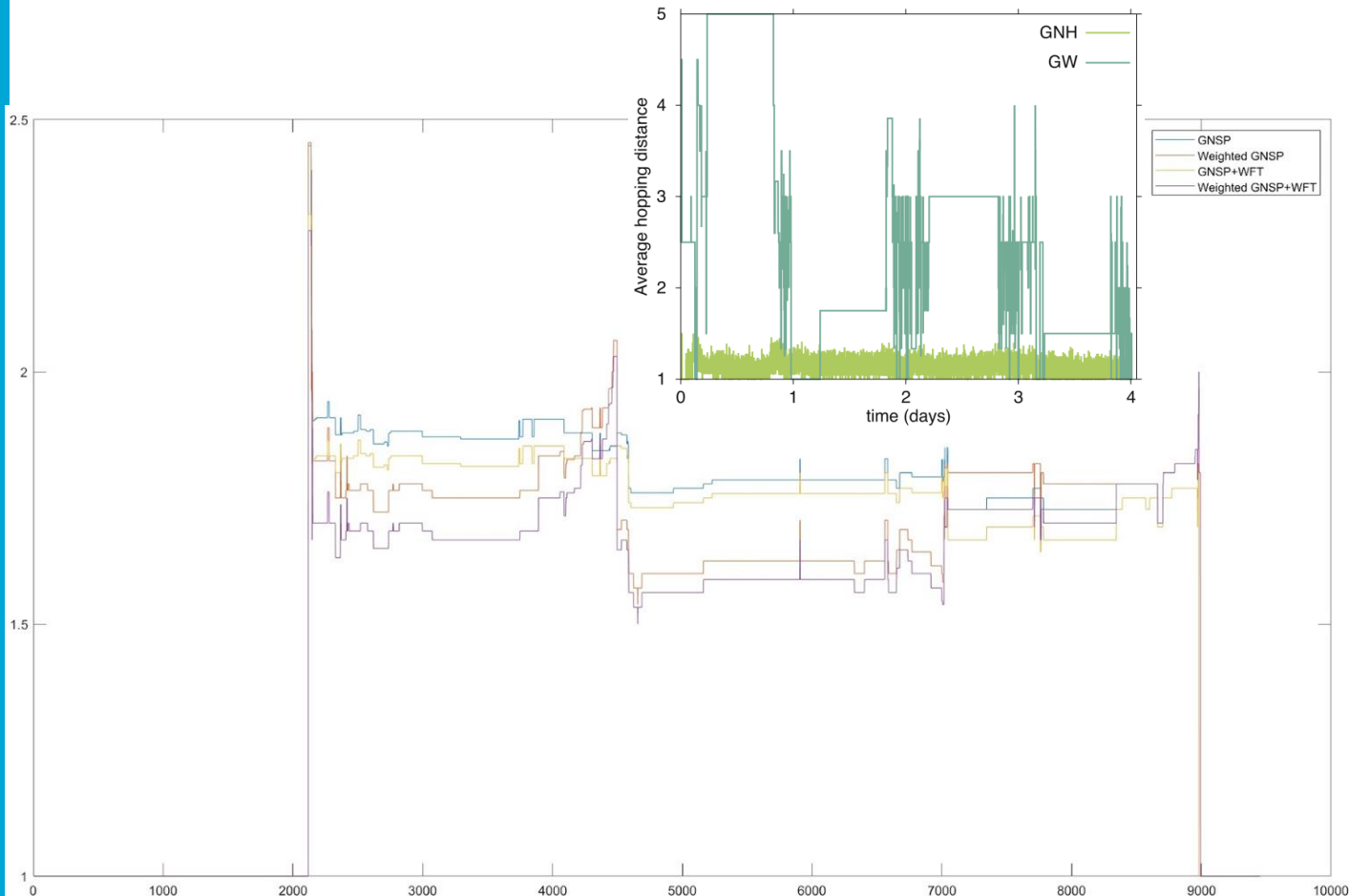
Reachability of Node 51

Background
WFM
GNSP
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Conclusion



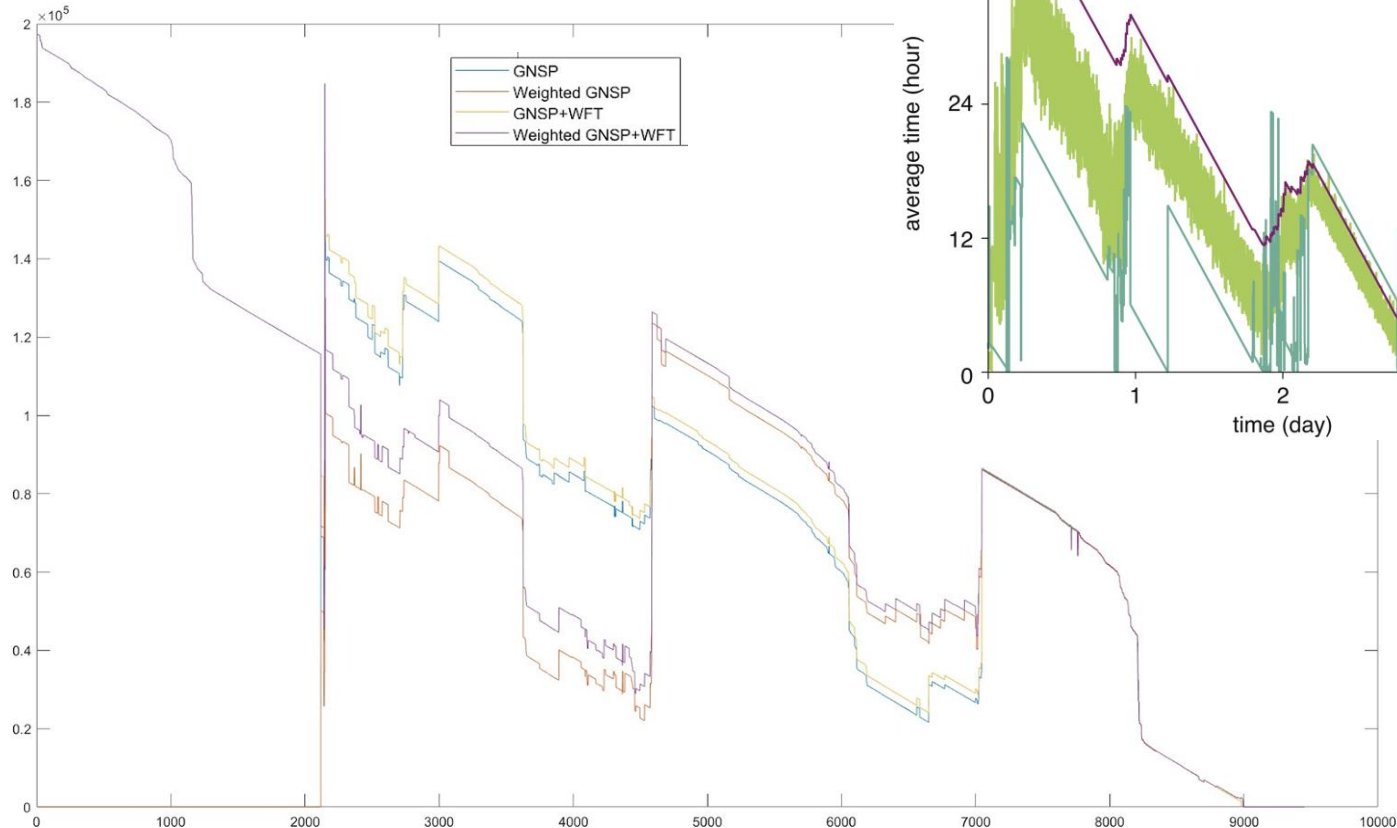
Average Hopping Distance of Node 51

Background
WFM
GNSP
Weighted
Conclusion



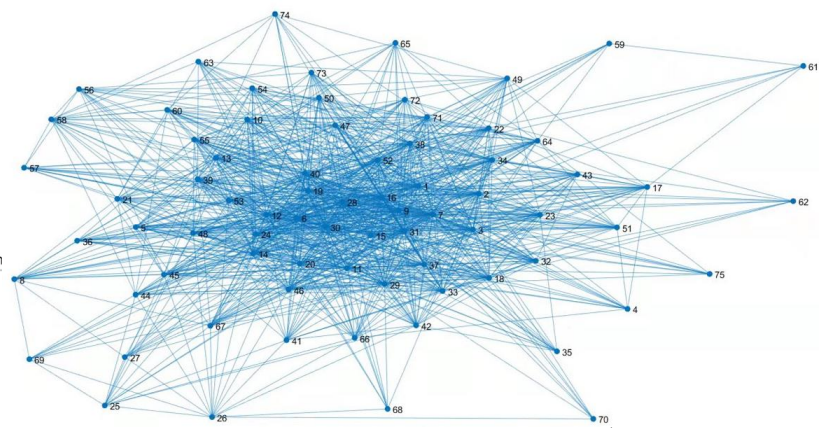
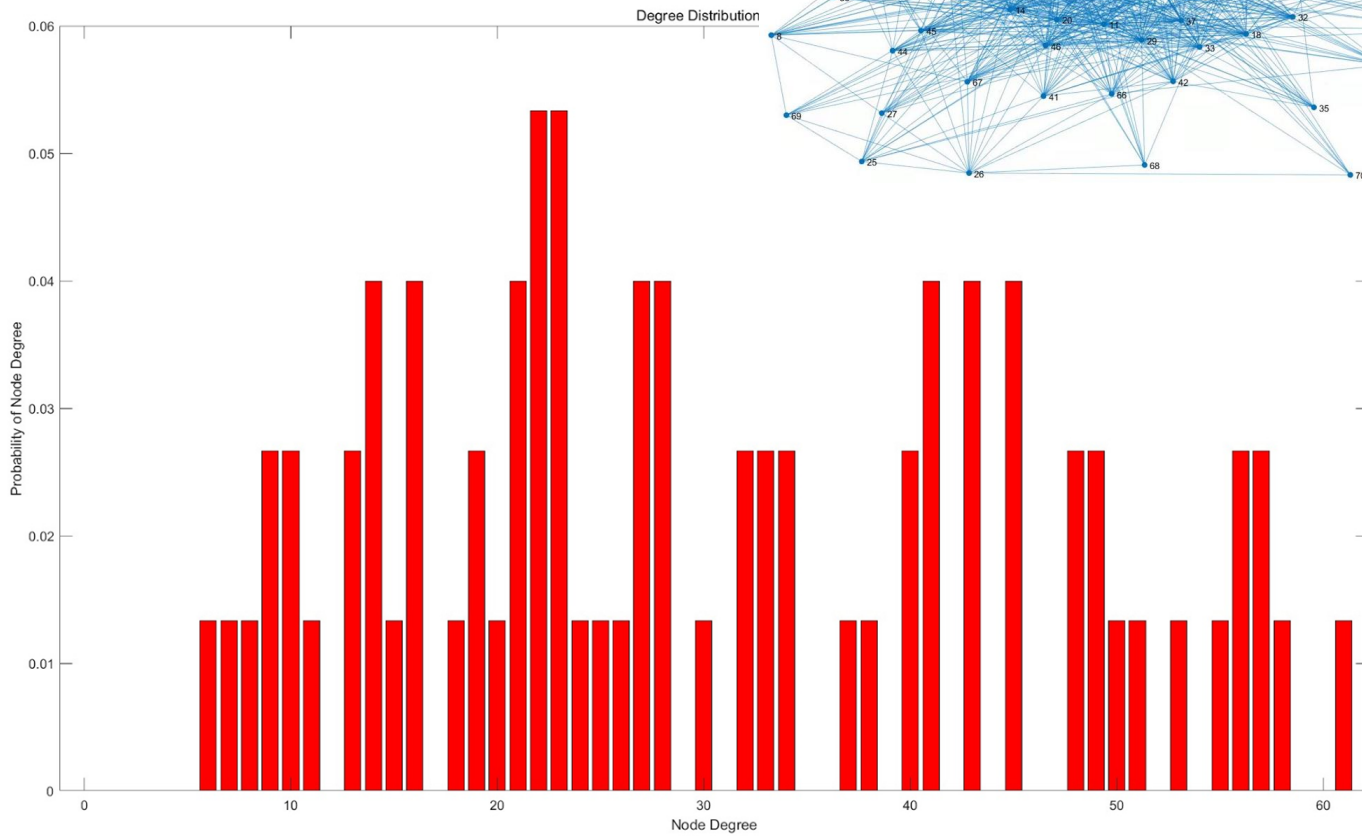
Average Time of Node 51

Background
WFM
GNSP
Weighted
Conclusion



Degree Distribution

Background
WFM
GNSP
Weighted
Conclusion



Conclusion

- Enhancement of maximum reachability up to 100% with WFM;
- Weighted networks improve performance in regarding to hopping distance and average time from GNSP;

Future work

- Trade-offs between reachability and hopping distance & average time.